Appendix B

Efficiency Comparisons

B-1. BACKGROUND. The procurement of liquid chillers is very difficult when trying to specify the best applicable energy efficiency. Efficiencies of liquid chillers vary greatly based upon a number of different factors. Some of the factors include:

a. Chiller type.

b. Site specific conditions (i.e., outdoor design temperatures, supply water design temperatures, etc.).

c. Commercial availability.

d. Heat recovery.

e. Refrigerant type (i.e., R-22, R-123, R-134a, etc.).

B-2. ENERGY EFFICIENT PRODUCTS. To encourage the procurement of energy efficient products where practical and cost effective, the President of the United States signed into law Executive Order 12902 on March 1994. The key items in the Executive Order which deals with the procurement of energy efficient products by federal agencies is presented below. The efficiency values presented in the designer's notes of the Corps of Engineers Guide Specification (CEGS) 15650 "CENTRAL REFRIGERATED AIR-CONDITIONING SYSTEM" were developed based upon Executive Order 12902.

> "Section 507.(a).(2) To further encourage a market for highly-energy-efficient products, each agency shall increase, to the extent practical and cost effective, purchases of products that are in the upper 25 percent of energy efficiency for all similar products, or products that are at least 10 percent more efficient than the minimum level that meets Federal standards. This requirement shall apply wherever such information is available, either through Federal or industry approved testing and rating procedures."

B-3. ENERGY PERFORMANCE TERMS. Efficiency rating procedures for liquid chillers are defined in ARI 550, ARI 560, and ARI 590 as applicable. The following paragraphs are explanations of typical terms used by ARI to define efficient ratings of liquid chillers.

a. Coefficient of Performance (COP). The COP rating of a liquid chiller is equal to the net equipment cooling capacity divided by the total power input to the unit, including controls. COP values are dimensionless.

b. Energy Efficiency Ratio (EER). The EER rating of a liquid chiller is equal to the net equipment cooling capacity divided by the total power input to the unit, including controls. EER values are expressed in Btuh/Watt. EER is typically used to rate the cooling efficiency of a liquid chiller running at full load conditions.

c. Integrated Part-Load Value (IPLV). The IPLV rating of a liquid chiller represents a single numeric representation of part load efficiency at different load points. The different load points of a chiller are determined based upon standard ARI rating conditions. The standard rating conditions are defined in ARI 550, ARI 560, or ARI 590 as applicable. IPLV values are expressed either as kW/ton or are dimentionless

d. Application Part-Load Value (APLV). The APLV rating of a liquid chiller represents a single numeric representation of part load efficiency at different load points. The different load points of a chiller are determined based upon site specific rating conditions. APLV values are expressed either as kW/ton or are dimentionless.

B-4. LIQUID CHILLER TYPES. Liquid chiller designs are either the vapor compression type or the absorption type. Both designs rely on a cycle of condensation and evaporation to produce cooling. Refer to the "ASHRAE HANDBOOK, Refrigeration Systems and Applications" for a thorough explanation of each type of chiller system.

B-5. CURRENT ENERGY MANDATES. Minimum energy performance standards for electrically-driven liquid chillers (vapor compression type) in federal buildings are defined in 10 CFR 435.108 and ASHRAE 90.1. The energy parameters are based upon the standard rating conditions established in ARI 550 and ARI 590. At the time of publication of this ETL, minimum energy performance standards for other types of liquid chillers (i.e., absorption type chiller, gas engine-driven type chillers, etc.) were not specifically mandated by any federal regulations.

B-6. CHILLER EFFICIENCIES. Because of typical manufacturing practices, most liquid chillers are not available in multiple efficiencies for each available capacity. Only one model, and therefore, only one efficiency is available from a manufacturer for a given capacity. This is not the case; however, for large electrically-driven, water-cooled rotary screw or centrifugal type chillers (typically larger than 200 tons capacity). These type chillers can be supplied by manufacturers in numerous efficiencies for each capacity.

B-7. CURRENT ARMY CRITERIA. The Corps of Engineer's Guide Specification (CEGS) 15650 "Central Refrigerated Air-Conditioning System" contains the Army's current recommendations for minimum energy efficiencies for all types of liquid chillers. The recommendations in CEGS 15650; however, are not based upon the best commercially available chiller efficiencies. The recommendations are intended to meet or exceed any current energy mandates while also allowing competitive bidding among multiple manufacturers.

B-8. CHILLER PROCUREMENT. In the procurement process of a liquid chiller, minimum specification requirements (including efficiency) will be developed using CEGS 15650. In addition, the procurement contract should include a bid option that will allow each bidding Contractor the ability to supply an additional proposal(s) at no additional cost to the Government for providing a more efficient chiller than is specified. The Contractors must identify the first cost and efficiency of each additional proposal. In review of the Contractors' proposals, a designer can compare and evaluate the baseline chiller proposals (per the specification) along with each of the additional chiller proposals. The designer will have to perform an economic comparison between each of the proposals in order to determine the optimum efficiency to select.

B-9. SAMPLE ECONOMIC COMPARISON. In comparing various chiller proposals, the designer must keep in mind that the chiller with the best part load or full load efficiency is not always the optimum chiller to select. Factors such as chiller first cost, chiller energy usage, available energy costs, etc. will all be influential in the chiller selection. As an example, refer to Appendix C for an economic comparison of various electrically-driven, water-cooled 200 ton centrifugal chillers.